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Public Investment and Economic Growth in Mexico

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Mexico's government has learned that the only way to ensure that the public investment program contributes significantly to growth is by maintaining a high quality of investments. This means paying attention to rate of return and clearly distinguishing between the roles of the public and private sector.

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Summary findings

Mexico's growth rate began to plummet at roughly the same time that its public investment expenditures declined. That decline also appears to coincide with a slowdown in the growth of infrastructure capital in the electricity, transport, and communications sectors. Because of these parallel developments, many economists have attributed at least part of the blame for the decline in Mexico's growth after 1981 to the decline of public infrastructure investment. The empirical results presented in this report provide only limited support for this argument. They also suggest, in turn, that increases in public investment would not automatically translate into faster output and productivity growth.

One reason not to take for granted a positive relationship between more public investment and faster growth is public investment's crowding out effect on private investment. Although the time-series regression results for Mexico all point toward a crowding out coefficient of less than unity, the existence of a significant crowding out effect limits the growth impact of public investment by reducing its net effect on capital accumulation.

The time-series results also suggest that the economy's total factor productivity growth responds positively to increases in the ratio of public to private investment. In light of that result, increases in public investment should have a positive net impact on economic growth, despite significant crowding out effects. Chow breakpoint tests indicate, however, that the positive productivity effect

appears to have weakened significantly in the past decade.

A third reason for questioning a stable relationship is that the impact of increased public investment is likely to depend on how it is financed. The cross-country regressions reported here indicate that a general increase in the public capital stock has a positive impact on growth only if financed through savings generated through lower public consumption expenditures, but not if financed through higher public debt, which implies higher current and future taxation levels. The scope for reducing public consumption expenditures in Mexico is very limited, however, since they are already at rock bottom levels. Therefore, the only way to assure that the public investment program makes a significant contribution to growth is by improving its "quality" through careful attention to its rate of return and complementarity with private capital.

In Mexico the most important reforms to make public investment more productive came from policymakers' recognition of the need to distinguish more clearly between the roles of the public and private sectors. This led to the privatization of most public enterprises and a reorientation of public investment to a more narrowly focused set of activities. In addition, the government took important steps to strengthen the institutional framework within which the public investment program is determined.

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PUBLIC INVESTMENT AND ECONOMIC GROWTH IN MEXICO

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Mexico's growth rate began to plummet roughly at the same time that its public investment level declined. That decline also coincided with a slowdown in the growth of infrastructure capital in the electric, transport and communications sectors; Feltenstein and Ha (1995). In view of these parallel developments, many economists have attributed at least part of the blame for Mexico's growth decline on the lack of adequate public investment.

The notion that public investment and economic growth are positively related is often taken for granted. It underlies, for example, the Mexican Government's official economic strategy for promoting growth in 1997 and 1998.¹ There are several reasons, however, for suspecting that such a relationship may not be stable or may only hold in certain circumstances. Identifying those circumstances is important from a policy viewpoint in order to ensure that public spending has the expected impact and does not lead to resource misallocation. The next section lists the main reasons why public investment can either have a positive or a negative impact on overall economic growth. This is followed by an empirical analysis of the impact of public investment in Mexico, using both a time-series and cross-country approach.

A. Supply-Side Links Between Public Investment and Growth

If public and private capital are perfect substitutes, an increase in public investment would have the same effect on growth as an increase in private investment. That is, both contribute to the accumulation of physical capital, which increases the capacity to sustain a higher level of output. An extra Peso spent on public investment, however, may not necessarily lead to an additional Peso in physical capital because public investment may displace or crowd out private investment. Such crowding out could happen in one of two ways: financially, if the public sector finances the increase in public investment with higher taxes or by borrowing in the domestic capital market, and physically, to the extent that the public sector investment exhausts market opportunities that could have been filled by the private sector. The first occurs when capital is not perfectly mobile internationally. In that case, public borrowing in the domestic capital market drives up domestic interest rates, which reduces private investment demand. The amount of physical crowding out, on the other hand, depends on whether the public investment involves "public" or private goods and, thus, substitutes for or is

¹ Economic Policy Guidelines (Criterios Generales de Política Económica) for 1997 (pg. 3) and 1998 (pg. 17). The latter states, for example, that the strategy for promoting economic growth rests on two fundamental pillars: the maintenance of favorable conditions to support higher private investment levels and continued impulses to public investment.

complementary to private investment. The international experience, as surveyed in a multi-country study by Easterly, Rodriguez and Schmidt-Hebbel (1994), suggests that it is far more common for public investment to crowd out than to crowd in private investment.²

Another way that public investment affects output growth is by influencing the rate of productivity growth, independent of its effect on factor accumulation. If public infrastructure capital is complementary to private capital, an increase in public investment would not only attract more private capital, thereby boosting factor accumulation, but it would also render private capital more productive. This effect is absent when public investment substitutes for private investment. In fact, it will even reduce overall productivity if public expenditures are made with less regard for appropriate procurement procedures than private investment. That is, a Peso of public investment will have bought fewer goods or machines than the same Peso invested by the private sector, so that the level of actual capital accumulation would be lower than the measured capital accumulation³ -- which in a growth accounting framework becomes reflected in lower productivity.

The same is true if public investment expenditures are made with less concern for efficiency and profitability than private investments. When measured by the amount spent, the public capital stock would overstate its true value, which is measured more appropriately by the discounted stream of returns. If, for example, public investments are directed to sectors or regions based mainly on an expected political payoff, their financial returns will obviously be lower than those of private investments primarily undertaken in response to profit incentives. Furthermore, to the extent that this public capital is not properly operated and maintained, the rates of return diminish even further.

Finally, the impact of public investment on growth may also depend on how that investment is financed. To the extent that an increment in public investment is financed through higher taxes or through increased public debt -- which spreads out the tax burden over time -- the net return of that investment is reduced by the distortionary impact that those taxes may have on the economy. That distortionary impact on growth also manifests itself through the two channels discussed previously: (i) on reduced factor accumulation, which occurs when higher taxes lead to a net reduction in total investment, and, (ii) on lower productivity, which occurs when investors shift to less socially

² Among their main findings and conclusions, the authors state, "The conventional wisdom that public investment is good for private investment is contradicted by the evidence in half of the case studies, where public investment has a negative and statistically significant effect on private investment. The negative association in some cases is explained by the likelihood that public investment is replacing rather than complementing private investment. Concentration of public investment on infrastructure and on privatization of other state enterprises would ensure a complementary relationship between the public and private sectors." (pg. 1).

³ Pritchett (1996), for example, provides calculations to show that in a typical developing country, less than 50 cents of capital is created for each public dollar invested.

profitable economic activities in order to evade government taxes. Estimates of the marginal costs associated with raising revenues from the least distortionary tax instrument in developed countries range from 32%-47% in the United States to 120% in Sweden. In developing countries, the marginal cost of public funds is likely to be even higher.⁴ Based on these findings, it is probably safe to assume that for Mexico there is a deadweight loss of at least half a Peso imposed on the economy for each Peso raised in taxes.

One direct indication of high deadweight losses in Mexico's tax system is given by the low productivity of its value-added tax (VAT). The VAT productivity ratio -- defined as the ratio of actual VAT revenues over GDP divided by the average VAT rate -- is widely regarded as an important indicator of the efficiency of revenue generation. As shown in Loayza and Palacios (1997, Chart 16), Mexico has one of the lowest (trade-adjusted) VAT productivity ratios in the region as well as the OECD. This ratio averaged 0.23 in Mexico during 1992-94 (and declined to 0.15 during the 1995 crisis), compared to an unweighted average ratio of 0.28 for Latin America and the Caribbean. This figure is substantially below the ratios observed, for example, in Argentina (31%), Brazil (47%), Chile (0.39) and Colombia (0.30), or in developed countries, where they lie between 0.30 and 0.70.

B. The Evolution of Public Investment in Mexico

Table 1 shows how public and private investment have evolved in Mexico since 1960. Public investment started out as a modest share of GDP in 1960, increased sharply in the 1970s, and then declined again in the 1980s and 1990s. This evolution reflects the evolution of economic strategies pursued in Mexico over this period: during the import substitution industrialization (ISI) strategy adopted in the 1960s, public investment focused on the development of key "strategic" industries, considered complementary to the overall industrialization effort; e.g., the electricity sector, railroads and irrigation systems. The rapid expansion of public investment in the 1970s, in turn, coincides with the indiscriminate proliferation and expansion of parastatals that accompanied the public sector-driven growth strategy implemented in the 1970s. This period is characterized by the expansion of various "white elephants", such as the public steel enterprise. The main boom in public investment spending, however, took place toward the end of the decade and focused on the petroleum sector, following the discovery of major oil deposits.

After peaking at 12 percent of GDP in 1981, Mexico's public investment experienced a progressive decline that continued until the mid-1990s. At first, this decline was driven by the exigencies of fiscal retrenchment and the drying up of foreign borrowing opportunities in the aftermath of the 1982 crisis. Starting in the mid-1980s,

⁴ These estimates are from Devarajan, Squire and Suthiwart-Narueput (1995), pg. 18, which also discusses various key factors that determine the marginal welfare cost of taxation.

however, the continued decline of public investment followed naturally from the government's new economic strategy, which was oriented toward creating a more private sector-based, market-friendly economy.

Table 1: Mexico -- Gross Fixed Investment
(constant prices, as % of GDP)

Years	Total	Private	Public
1960-1964	16.8	12.6	4.2
1965-1970	19.2	13.1	6.1
1970-1977	21.2	13.5	7.7
1978-1981	23.8	13.3	10.5
1982-1987	17.7	11.0	6.7
1988-1994	17.7	13.8	3.9
1995-1996	15.4	12.0	3.4

Source: INEGI, Sistema de Cuentas Nacionales, Serie 1960-93 and Serie 1988-96. World Bank, "Mexico After the Oil Boom" (Report # 6659-ME), 1987, for data in 1960-70.

The role of public investment under the new economic strategy is very different from what it had been before. To start, the decline in public investment is a natural consequence of the privatization of many state enterprises. Also, the new strategy sees the private sector as taking the lead in overall economic investment decisions and limits the state to a facilitating role in providing public infrastructure that complements private initiatives and to the correction of market failures. The latter calls for a refocusing of public investment in sectors considered to have important externalities (education, health, environment) and whose services are traditionally under-provided by the private sector. To permit a better prioritization of the public investment program in this sense, an "Investment Unit" was created in the Finance Secretariat in the early 1990s with broad review and clearance.

The change in strategy described above can be seen in Table 2 by noting the decline of public investment in the two productive sectors, Agriculture and Industry, Tourism & Commerce. Public investment in both sectors used to account for around 20% of total public investment in the early 1980s and currently accounts for around 7% of the total. Also, the falling share of the communication and transport sectors after 1990, reflects divestitures in the telecommunications sector. Conversely, the share of public investment in the social sectors (education, health, social security, labor, nutrition and social assistance, and urban and regional development) increased from less than 30 percent in the early 1980s to around 40 percent in the early 1990s. This share fell again in the latter half of the 1990s, but still remains significantly above the level in the 1980s. The sector that accounts for the greatest share of public investment is the energy sector, which is dominated by the two parastatals, PEMEX and CFE.⁵

⁵ Table 2 does not include public sector investments at the state and municipal levels, which represent between 15 and 20 percent of total public investment. INEGI breaks down total fixed investment into Construction and Equipment & Machinery, each of which is again sub-divided into public and private

The economic recession of 1995 placed further constraints on public investment. As the economy began to recover from the recession in 1996 and 1997, public investment was expanded modestly in real terms (though not as a share of GDP). This suggests that the government has been, by and large, sticking to its strategy of relying mainly on private sector-led growth. The only aspect that departs somewhat from this strategy is the investment in the energy sector. Recognizing that this sector does not share the “public good” attributes of the social sectors, the Government had announced in 1995 a program of progressive divestiture and increased private sector participation in the “secondary” petrochemicals and electricity sub-sectors. Nevertheless, public investment in the energy sector now occupies an even higher share of the public investment budget than it did in the early 1980s. As a share of GDP, however, it appears to have declined to half the level in the early 1980s, but these figures are misleading because they do not include the recently introduced “proyectos financiados”.⁶

Table 2: Sector Composition of Public Investment in Mexico

(as % of total public investment)

	Agriculture & Nat. Res.	Social	Comm. & Transport	Energy	Industry, Com. & Tour.	Other
1982-1985	11.7	27.4	13.5	36.0	7.5	3.8
1986-1990	7.9	28.9	18.4	34.1	6.2	4.5
1991-1994	6.7	41.0	11.2	33.4	1.0	6.7
1995	5.1	36.8	12.0	40.3	0.9	4.9
1996	5.7	34.3	11.8	40.9	--	7.4
1997	6.6	33.6	9.6	44.4	--	5.9
1998 ^B	7.2	35.0	9.4	42.7	--	5.6

Note: All figures refer to executed federal expenditures, except for 1998, which refers to budgeted.

Source: Presidencia de la República, “Informe de Gobierno, various issues, and “Proyecto de Presupuesto de Egresos de la Federación para el Ejercicio Fiscal, 1998.

In 1997, the Mexican Government introduced a new modality for public investments, termed “proyectos financiados”, which is based on “Build-Operate-Transfer” or “Build-Lease-Transfer” principles. These investments are not explicitly included in the fiscal budget (although they do require Congressional authorization) and, therefore, are not captured by the figures in Table 2. “Proyectos financiados” consist of

investment. Public investment in Construction is further subdivided into central government, social security and para-statal enterprises (all of which are captured in the figures in Table 2) and local government (comprising the state and municipal levels not captured in Table 2). No such subdivision is available for public investment in Equipment & Machinery, though it is conjectured that most public investment under this rubric takes place in the parastatal enterprises.

⁶ It is important in this context to separate the issues of efficient spending versus sector management. Arguably, the energy sector could benefit from greater private sector participation. Being a productive sector, however, sectoral investments should be guided primarily by rates of the return in the sector, independent of whether it is the private or public sector that carries out the investment. That is, if rates of return are adequate, sector investments should be insulated from public spending cutbacks.

long-term income-generating investment projects commissioned by the government, but financed by the private sector, which is to be repaid from the proceeds from the operation of the project. It is not clear to what extent these projects represent a fiscal liability, even though they do not involve immediate fiscal outlays. Moreover, the “BLT” arrangements also raise questions about the extent of private participation involved, other than in the construction itself, and consequent implications for competition in the sector. The amounts involved are significant: for 1997, the Mexican government had programmed 24 billion Pesos (equivalent to 24 % of the 1997 public investment budget) in “proyectos financiados” in the hydrocarbons, electricity and highway sectors. These projects are expected to represent an increasing share of public investments devoted to income-generating projects.

C. Public Investment and Economic Growth: Time Series Analysis

Crowding out or crowding in? The discussion in Section A indicated that the impact of public investment on economic growth can be positive or negative, depending on the circumstances under which it is carried out. The preceding overview indicates that these underlying circumstances have varied significantly in Mexico over the last four decades, so that its impact is likely to have varied accordingly over time. Even so, Mexico’s experience in this regard is shown below to broadly mirror the international experience described in Easterly et al (1994), which found that public investment has tended, on balance, to exert a crowding out effect on private investment.

The equations in Table 3 describe the results from regressing private investment (I^p) on the consolidated public sector expenditures (E^G), which are decomposed into public investment (I^G) and government consumption expenditures (C^G), on consolidated public sector revenues (R^G) and GDP (Y), using simple least squares.⁷ The regressions are based on annual data from 1970 to 1996 from the national income accounts. These series are non-stationary, so the regressions were carried out on the differenced variables to avoid spurious correlation. The equations in Table 3 were also reestimated with Two-Stage-Least Squares, under the assumption that GDP was also an dependent variable (not shown here). This different procedure did not appreciably change the results.

Three issues are of interest in light of the earlier discussion: (a) whether public investment crowds out or crowds in private investment, (b) whether that impact occurs solely through its impact on the overall deficit (which leads to financial crowding out), or whether public investment exerts an additional influence, and (c) whether there has been any break in these relations after the Government embarked on its new economic strategy in the mid-1980. The main findings from the regression with regard to these issues are described next:

⁷ These equations are similar to the ones estimated by Rodriguez (1994) for Argentina.

Table 3: The Crowding Out of Private Investment in Mexico

$$(1) \Delta[I^P] = -54.67 + 0.548\Delta Y + 0.010\Delta C^G - 0.455\Delta I^G - 0.032 \Delta R^G$$

$$(13.06)^* (0.084)^* (0.072) (0.238)^{**} (0.099)$$

Unadjusted

$R^2 = 0.81$, D.W. = 0.92, F-stat = 21.79, No. of obs. = 26

$$(2) \Delta[I^P] = -66.71 + 0.628\Delta Y + 0.062\Delta C^G - 0.573\Delta I^G - 0.054 \Delta R^G$$

$$(22.17)^* (0.051)^* (0.059) (0.162)^* (0.080)$$

Adjusted for autocorrelation

$R^2 = 0.89$, D.W. = 1.79, F-stat = 30.51, No. of obs. = 25, AR(1) = 0.69*

$$(3) \Delta[I^P] = -50.42 + 0.487\Delta Y - 0.041\Delta DEF^G$$

$$(16.66)^* (0.043)^* (0.060)$$

Adjusted for autocorrelation

$R^2 = 0.82$, D.W. = 1.99, F-stat = 32.15, No. of obs. = 25, AR(1) = 0.48*

$$(4) \Delta[I^P] = -101.45 + 0.697\Delta Y + 0.040\Delta C^G - 0.627\Delta I^G - 0.016\Delta R^G + 47.0 DUM - 0.721 DUM * \Delta I^G$$

$$(19.37)^* (0.065)^* (0.060) (0.162)^* (0.080) (23.93)^{**} (0.446)$$

Adjusted for autocorrelation

$R^2 = 0.92$, D.W. = 1.45, F-stat = 28.14, No. of obs. = 25, AR(1) = 0.53*

Notes. These regressions are based on annual data from 1970-1996, obtained from the same source as Table 1. The figures in parentheses denote standard errors. The asterisk * (**) indicates that the coefficient is significantly different from 0 at the 5% (10%) level. Δ denotes differences.

- Regression equations (1) and (2) indicate that public investment has a negative and significant impact on private investment, suggesting that it exerted a crowding out, rather than crowding in effect in Mexico. Furthermore, the size of the crowding out effect has been significant: Regressions (1) and (4) indicate that private investment is crowded out by a factor of around one-half of the change in public investment.⁸
- To examine whether the relation between private and public investment might be non-linear, the change in public investment was added in quadratic form to the list of explanatory variables in all the equations in Table 3, but the associated coefficients were not significant.

⁸ While the regression equations in Table 3 gave the best fit, it is necessary to point out that the crowding-out coefficient is very sensitive to the inclusion or exclusion of other variables, notably GDP, among the explanatory variables. This suggests that there may be significant cyclical covariation in the variables.

- The estimated coefficients on government consumption and revenues are of the “wrong” sign, but they are not significant. This finding suggests that public investment has a stronger crowding out effect on private investment than is accounted for through its impact on the government deficit. This finding is confirmed by a (Wald) coefficient test, which rejects the hypothesis that $c(2) = c(3) = -c(4)$; where $c(i)$ refers to the i th coefficient on the right hand side of equation (1). It is also confirmed by regression (3), which imposes this parameter restriction. Although the sign of the coefficient on the government deficit is negative, as expected, its level of significance is very low.
- A Chow breakpoint test applied to the least restrictive regression equation (1) indicates that the hypothesis of a structural break in 1986 cannot be rejected (at the 10% level). Regression (4) reestimates regression equation (2) with a dummy variable to capture changes in the coefficient on public investment after 1985. Contrary to expectation, this yielded a negative sign for the coefficient on $DUM \cdot \Delta I^G$, indicating that the crowding out effect of public capital increased since 1985. But the significance level of that coefficient is not high. One possible reason for this lack of significance is that the reform program was too recent to exert a noticeable impact in the regressions. For example, even though the public divestiture program began in 1983, the bulk of the privatizations took place after 1989.

The preceding estimation results suggest that on average public investment has crowded out private investment in Mexico.⁹ Although there remains considerable uncertainty about the true size of the crowding out coefficient on public investment, it turns out to be less than unity in all the regressions, which means that the expansion of public investment results in an expansion of total investment, even though not on a one-for-one basis. In other words, an expansion of public investment should still have a positive effect on overall capital accumulation, which, in the absence of any productivity decline, should lead to faster growth. This last proviso is very important and will be examined next.

Does public investment affect productivity growth? Whether or not public investment exerts an influence in addition to its net impact on factor accumulation, can be tested by examining whether the economy’s total factor productivity responds positively or negatively to changes in the ratio of public to private investment. As discussed in Section A, such a response can be negative, if public capital is less productive or procured more expensively than private capital, or positive, if public capital is complementary to private capital. The regressions in Table 4 are based on two alternative

⁹ This conclusion conforms with the cross-country findings of Easterly et al (1994), who report (pg. 59) that “Consistent with the theoretical ambiguity of the relationship between public capital and private investment, the case studies found sharply different results. [...] It seems reasonable to infer, then, that for countries with a negative relationship (Chile, Colombia, Ghana and Mexico) or no relationship at all (Argentina), public investment is concentrated in activities which substitute directly for private investment.”

measures of total factor productivity (TFPlow and TFPhigh).¹⁰ Initial diagnostic tests pointed toward a first-order integrated process, so that all variables are expressed as differences in the regressions.

The estimation results in Table 4 indicate that the ratio of public to private investment is positively correlated with total factor productivity growth, and generally significant, which suggests that public capital has exerted positive externalities for the private capital that was not crowded out. As before, the public-private investment ratio was included in squared form among the explanatory variables to test for a possible non-linearities in the relationship, but this yielded insignificant coefficients in all cases.

Table 4: Public Investment and Total Factor Productivity in Mexico

<p>(1.a) $\Delta(\text{TFPhigh}) = -0.010 + 0.167 \Delta(I^G / I^P)$ (0.005) (0.059)*</p> <p>$R^2 = 0.25, \text{ D.W.} = 1.62, \text{ F-stat} = 7.93$</p>	
<p>(1.b) $\Delta(\text{TFPhigh}) = -0.008 - 0.004 \text{ DUM} + 0.167 \Delta(I^G / I^P) - 0.102 \text{ DUM}^* \Delta(I^G / I^P)$ (0.005) (0.010) (0.056)* (0.041)*</p> <p>$R^2 = 0.43, \text{ D.W.} = 1.51, \text{ F-stat} = 5.19$</p>	
<p>(2.a) $\Delta(\text{TFPlow}) = -0.009 + 0.134 \Delta(I^G / I^P)$ (0.004) (0.052)*</p> <p>$R^2 = 0.21, \text{ D.W.} = 1.71, \text{ F-stat} = 6.54$</p>	
<p>(2.b) $\Delta(\text{TFPlow}) = -0.007 - 0.003 \text{ DUM} + 0.137 \Delta(I^G / I^P) - 0.092 \text{ DUM}^* \Delta(I^G / I^P)$ (0.005) (0.009) (0.050)* (0.037)*</p> <p>$R^2 = 0.40, \text{ D.W.} = 1.51, \text{ F-stat} = 4.66$</p>	

Source: Same as Table 3 and Bosworth (1997). Each regression is based on 26 observations referring to annual data from 1970 to 1995. Terms in parentheses are standard errors. Asterisks indicate significance at 5%.

Finally, Chow tests pointed to a significant break in the mid-1980s. In contrast to the earlier results, this time the coefficients associated with the Dummy variables indicate a significant change in the relation between productivity and the public-private investment ratio. In particular, the results indicate that the positive relationship between both variables appears to have weakened after 1985. This comes as a surprise again: as discussed earlier, the existence of a positive relationship between both variables can be interpreted to imply a certain complementarity between public and private

¹⁰ Both measures of total factor productivity are aggregative concepts derived in the standard manner as a residual after netting out the contribution of factor accumulation. To derive these residuals, output is measured by GDP, labor input is measured by the economically active labor force, and the physical capital stock is constructed using a perpetual inventory method with two alternative depreciation rates; 6% (low) and 12% (high).

investment. The refocusing of public investment priorities in line with the government's new economic strategy after 1985 was intended to increase the complementarity between public and private investment. It is surprising, then, that this relationship should have weakened. Again, a possible answer is that the reforms are still too recent to have exerted a noticeable impact. Alternatively, this result may be reflecting an interaction with omitted variables that are exerting a downward influence of total factor productivity growth in the early 1990s.¹¹

The finding that public investment generally has been positively related to TFP suggests that the considerations about the potential mismeasurement and relative inefficiency of public capital do not, on average, appear to have been empirically significant in Mexico. Some circumstantial evidence that supports this finding is a reasonably close correspondence between the perpetual inventory-based monetary measures of the capital stock produced by the Banco de Mexico for the electricity, transport and communications sectors and physical measures of public capital capacity in these sectors (e.g., kilowatt hours of electricity production).¹² In each case the monetary measures capture the substantial growth in physical capital which occurred from 1970 to 1990 (or, in the case of telecommunications, from 1975 to 1990). Taking into consideration that the monetary measures of public investment spending include expenditures on capital items that are not directly represented by the particular physical measures (e.g., transportation capital includes more than the number of kilometers of roads and rail), we can conclude that the monetary measures are acceptable proxies for the true public capital stock in the case of Mexico.

D. Public Capital and Economic Growth: A Cross-Country Perspective

A large body of empirical research has investigated the static impact of changes in the stock of public capital on economic performance; Aschauer, 1997. The main focus of that research has been to determine the importance of public infrastructure on the private sector's productive capacity, to its costs of production and/or to its level of profitability. By and large, this research concludes that public capital exerts an important positive influence on the performance of the private sector economy. But these findings - which are static in nature -- have left open the question of the dynamic, or long run, effects of public capital on the economy.¹³ More recent attempts to capture the dynamic

¹¹ The existence of such influences is discussed in the 1998 World Bank's Country Economic Memorandum on Mexico: Enhancing Factor Productivity Growth. It draws attention to the failure of Mexico's productivity growth to recover as quickly as in other countries after inflation was stabilized and structural economic reforms had been implemented.

¹² A note of caution is in order here: The disaggregated capital stock series used for this comparison are based on an earlier constant price series, with base-1970, produced by the Banco de México. These series were recently re-based (to base year 1980), which resulted in significant revisions in some individual series (notably Communications), while the series for the Electricity sector was discontinued.

¹³ The few empirical studies that have focused on the Mexican economy (e.g., Shah, 1992, Feltenstein and Ha, 1995, and Nazmi and Ramirez, 1997) are of this type. They investigate the relationship between

effects of public capital on economic growth have identified a positive empirical link in this context. These have mostly relied on data from the United States and other developed countries, however, which limits their suitability for estimating the impact of changes in Mexico's public capital stock on output growth. The analysis below, therefore, estimates a growth equation based on data for 46 developing countries with similar levels of output per capita as Mexico.

Theory

The growth equation below is derived from the (Robert) Solow-inspired analytical framework elaborated by Mankiw, Romer and Weil (1992) and Hulten (1996). That framework departs from a simple neoclassical production function, written here for simplicity in a Cobb-Douglas specification with labor-augmenting technical progress:

$$(1) \quad Y = F(K^P, EK^G, H, L) = (K^P)^{a_P}(EK^G)^{a_G}(H)^{a_H}(AL)^{(1-a_P-a_G-a_H)}$$

where, Y denotes aggregate output, K^P and K^G denote the private and public capital stocks, H stands for human capital, L is the stock of labor, A denotes the level of total factor productivity and E is an index of the efficiency of use of public capital. Dividing both sides of the equation by AL and taking natural logs yields,

$$(2) \quad y = f(k^P, k^G, e, h) = a_c + a_P k^P + a_G k^G + a_E e + a_H h,$$

where all variables except 'e' are now expressed in terms of "effective" units of labor.

The evolution of the capital stocks is assumed to obey the following simple formulation:

$$(3) \quad d(K^Z/AL)/dt = s_Z Y/AL - \lambda(K^Z/AL) \quad \text{for } z = P, K, H.$$

where s_Z represents the savings (and investment) rate associated with the capital stock z , and λ represents the effective rate of depreciation, equal to the sum of the rates of population growth (n), technological progress (g) and of the physical depreciation of capital (δ). The economy modeled by this framework has the characteristic of converging to a steady state solution, given by the point where, $d(K^Z/AL)/dt = 0$ for all z . From (3), this yields that the steady state value of capital is $K^Z/Y = s_Z/\lambda$, which, when expressed in natural logs, yields $k^{z*} = \ln(s_Z/\lambda)$, where the asterisks denote steady state values.

Along the transition path from an arbitrarily given starting point, $y(0)$, the level of output is governed by the following equation:

$$(4) \quad y(t) = (1 - e^{-\mu t})y^* + e^{-\mu t}y(0),$$

where μ turns out to be equal to $\lambda(1 - a_p - a_G - a_H)$. Inserting the steady state solution emerging from this framework into the above equation leads to the following growth expression corresponding to the earlier output function (2):

$$(5) \quad y(T) - y(0) = b_c + b_Y y(0) + b_P \ln(s_P/\lambda) + b_G \ln(s_G/\lambda) + b_E e + b_H \ln(s_H/\lambda),$$

where (s_z/λ) , for $z = P, G$, and H , can be taken from equation (3) to represent the steady-state levels of private, public and human capital, expressed as shares of GDP. Those capital stocks are not directly observable, whereas this equation is expressed entirely in terms of measurable variables -- real GDP per capita, investment rates for different capital stocks, the “effective” depreciation rate and an efficiency index, to be defined later. The variables $y(T)$ and $y(0)$ represent the (log) level of output per capita in the terminal year and in the initial year chosen for the empirical analysis. The difference, therefore, denotes the rate of growth of output per capita over the entire period, T . Since the growth expression (5) is derived from the production function (2), the growth elasticities (i.e., the b 's in (5)) are related to the output elasticities (the a 's in 2) according to the following formula: $a_z = b_z / (b_P + b_G + b_H - b_Y)$, for $z = P, G, H$.

According to this model, output grows in the steady state at the same rate as population growth plus the rate of technological change. A permanent change in the per-capita level of one of the capital stocks changes the steady state level of the output per capita. In the new steady state, output per capita grows at the same rates as in the old steady state. However, during the transition, from one steady state to the other, the growth rate is different. The growth impact discussed below refers to this transitional change of growth, which depends on two factors: the distance between the old steady state equilibrium and the new one (which in turn depends on how much the steady state capital stock is changed) and on the rate of convergence (i.e., the rate at which the economy moves from one to the other steady state equilibrium), which is determined by the coefficient on initial output per capita, b_Y .

The Estimated Equation

The basic growth equation that is estimated below is given by equation (5), which has been augmented by two additional variables:

$$\begin{aligned} y(T) - y(0) = & b_c + b_Y y(0) + b_P \ln(s_P/\lambda) + b_G \ln(s_G/\lambda) + b_H \ln(s_H/\lambda), \\ & + b_E e + b_D (\text{DEBT}/Y) + b_C (\ln(C^G/Y)), \end{aligned}$$

where $y(\cdot)$ represents the natural log of GDP per capita, the s_z 's represent investment ratios associated with each capital stock, λ refers to the “effective” depreciation rate, ‘ e ’ is an index of efficiency of public capital use, DEBT/Y is the ratio of foreign debt to GDP, and C^G/Y is the ratio of public consumption expenditure to GDP. As discussed before, the first set of variables on the right hand side of the growth equation are proxies referring

to the three types capital stocks that are assumed to influence growth. The second set of variables on the right hand side of the equation are included in the regressions to capture the impact of differences in efficiency of public capital utilization and in the financing of public capital, as explained in more detail below.

The parameters of the growth equation are estimated with data for 46 developing countries over the period 1970-1990, from the data set in Easterly and Rebelo (1993) and various issues of the World Bank's World Development Report.¹⁴ (Accordingly, note that since $y(\cdot)$ is expressed in natural logs, $y(T) - y(0)$ represents a growth rate over a 20-year time interval, T .) Private and public investment rates (expressed as shares of output) were averaged for each country over the period 1970-1990 and then deflated by the average effective depreciation rate over that period to generate proxies for the private and public capital stocks. It is pertinent to note that public capital as defined here does not correspond directly to the definition of infrastructure capital. In most countries, the bulk of transportation, power and other public infrastructure facilities are publicly owned, but in several countries, some of these facilities are partly privately owned. Human capital is proxied by secondary education enrollment rates averaged over the same 20-year period.

Hulten (1996) drew attention to the importance of taking into account the efficiency with which the public capital stock is being used, along with the absolute amount of that stock. To capture this effect, a continuous measure of public capital efficiency across countries has been constructed on the basis of the four indicators used in Hulten (1996) and obtained from the 1995 World Development Report. The four indicators are (i) mainline faults per 100 telephone calls for telecommunications, (ii) electricity generation losses as a percent of total electricity output, and (iii) the percentage of paved roads in good condition and (iv) diesel locomotive utilization as a percentage of the total rolling stock. Each of these indicators was normalized so that performance in a particular category is measured in terms of standard deviations from the cross-country average level of performance. Then a simple average across performance indicators was taken to obtain an aggregate index for each country.¹⁵

As discussed at the beginning, the impact of public capital on economic growth is likely to vary according to how it is financed. There are two basic options considered in the growth equation estimated below. One is debt finance, which implies a higher level of taxes (and its distorting consequences). The other option is the reorientation of public expenditures from government consumption to investment spending, which would maintain the level of debt and taxation constant. Following Barro

¹⁴The 46 developing countries used in these regressions coincide with the same sub-set of countries used in Hulten's (1966) analysis.

¹⁵It is interesting to note that Mexico ranked second highest among the 46 developing countries in terms of the public capital efficiency index. (Mauritius ranked the highest and Nigeria ranked last.) The parameters underlying Mexico's efficiency index are (a) 13% of electric power generation output is lost, (b) 85% of paved roads are in good condition, and (c) 64% of diesel inventory is in use.

(1990), the impact of financing is incorporated into the estimation equations through two additional variables: the external public debt,¹⁶ expressed as the (absolute) ratio of total output, and the (natural log) ratio of public consumption expenditures to total output. Table 5 provides the sample average and Mexico-specific values of some key variables.

Table 5:
Average values for 46 developing countries and Mexico

	(s_G/λ)	(s_P/λ)	(C^G/Y)	DEBT/Y	λ
Sample average	1.08	1.35	0.18	0.30	0.076
Mexico	1.07	1.73	0.08	0.21	0.075

Note: these averages pertain to the period 1970-1990.

Estimation Results

The first set of four equations in Table 6 presents the basic estimates of the growth equation, using only the various capital stocks as explanatory variables. The main result here is that the direct impact of a change in the public capital stock is almost identical to that of a change in the private capital stock; and both are significant. Another noteworthy result, of interest more from a technical perspective, is that the assumption of constant returns to scale is not rejected by the data. (Under constant returns to scale the coefficient on the effective depreciation rate should be 0). This last result carries through in all subsequent equation specifications.

The second set of equations, (5) - (8), shows the effect of incorporating all the other variables as well into the growth equation. In all cases, the efficiency index has a positive and highly significant impact. Both financing variables are also statistically significant (most of the time) and have the expected negative sign. That is, higher public debt levels are associated with lower rates of growth, as are higher levels of government consumption. Another consequence of introducing both variables is that the growth elasticity of public capital regains its statistical significance, albeit the size of the impact is somewhat smaller than before.

A number of tentative conclusions can be drawn with respect to the relationship between public capital and economic growth on the basis of equation (7) in Table 6, which yields the best fit for the entire cross-country sample.¹⁷ [In the comparative statics exercises described next, it is convenient to remember -- from equation 3 earlier -- that the investment ratios in Table 6 may be interpreted as the natural log of the steady-state capital-output ratios; i.e., $(s_Z/\lambda) = \exp(k^Z) = (K^Z/Y)^*$.]

¹⁶It would have been preferable to use total (i.e., internal and external) public debt as a measure of the burden of financing public capital, but comparable data on internal debt is not available for many countries.

¹⁷As usual, in drawing such conclusions from cross-country data it is implicitly assumed that all countries share the same structural parameters (i.e., the production function elasticities), and only vary with regard to the behavioral parameters.

Table 6: Public Capital and Economic Growth(Dependent Variable = $y(90) - y(70)$; Standard Errors in parentheses)

<i>Regression independent variables</i>	1	2	3	4	5	6	7	8
Constant	0.88 (0.57)	1.20 (1.42)	1.42 (0.56)	1.53 (1.41)	1.29 (0.43)	1.54 (1.07)	1.63 (0.42)	1.89 (1.04)
y(70)	-0.38 (0.10)	-0.38 (0.10)	-0.36 (0.10)	-0.36 (0.10)	-0.41 (0.09)	-0.41 (0.09)	-0.39 (0.08)	-0.39 (0.08)
total capital ($\ln((s_F + s_G)/\lambda)$)	0.67 (0.18)	0.68 (0.18)	---	---	0.39 (0.18)	0.39 (0.18)	---	---
private capital ($\ln(s_F/\lambda)$)	---	---	0.31 (0.11)	0.31 (0.11)	---	---	0.20 (0.08)	0.20 (0.08)
public capital ($\ln(s_G/\lambda)$)	---	---	0.30 (0.11)	0.30 (0.11)	---	---	0.22 (0.10)	0.29 (0.11)
Human capital ($\ln(s_H/\lambda)$)	0.27 (0.07)	0.28 (0.07)	0.25 (0.07)	0.25 (0.07)	0.20 (0.05)	0.21 (0.06)	0.18 (0.05)	0.19 (0.06)
Efficiency (e)	---	---	---	---	0.28 (0.07)	0.28 (0.08)	0.26 (0.07)	0.26 (0.07)
debt ratio (DEBT/Y)	---	---	---	---	-0.28 (0.18)	-0.29 (0.19)	-0.41 (0.18)	-0.42 (0.19)
public consumption ($\ln(C^G/Y)$)	---	---	---	---	-0.33 (0.13)	-0.32 (0.13)	-0.29 (0.13)	-0.29 (0.13)
effective depreciation ($\ln(\lambda)$)	---	0.13 (0.24)	---	0.04 (0.53)	---	0.10 (0.41)	---	0.10 (0.39)
adj. R²	0.43	0.42	0.45	0.44	0.69	0.68	0.71	0.71
Standard Error (SER)	0.31	0.31	0.31	0.31	0.23	0.24	0.22	0.22

Aschauer (1997)

- Debt-financed public capital increase -- increases in the public capital stock, financed entirely through the issuing of debt would lead to lower growth. This result is derived by taking the following derivatives of the estimated growth equation under the condition that $d(K^G/Y)^* = d(DEBT/Y)$ and inserting the Mexico-specific parameters from Table 6.¹⁸

¹⁸ The following expression states that a 10 percent increase in the steady-state ratio of public capital to GDP (i.e., $d(\ln((K^G/Y)^*)) = d(\ln(s_G/\lambda)) = 0.10$) reduces the (20-year) growth rate by $-2.0^*(s_G/\lambda)$. Using the Mexico-specific parameters in Table A4.1, which refer to averages over 1970-90, the public investment ratio was around 8 percent of GDP. This yields a decline in the 20-year growth rate by -2.14 percent. Translated into an annual growth rate, this represents a decline of roughly 0.1% per year. Currently, the investment ratio is only around 3.5 percent. Hence, a 10 percent increase in the

$$\frac{d(y(T) - y(0))}{d(s_G/\lambda)} = \frac{b_G}{(K^G/Y)^*} - b_D = \frac{0.22}{1.07} - 0.41 = -0.20$$

- Consumption-financed public capital increase -- increases in the public capital stock, financed through the reduction in government consumption expenditures (thereby leaving the budget deficit intact) would lead to higher growth. To obtain this results, take the following derivative under the condition that $d(K^G/Y)^* = -d(\exp(C^G/Y))$:¹⁹

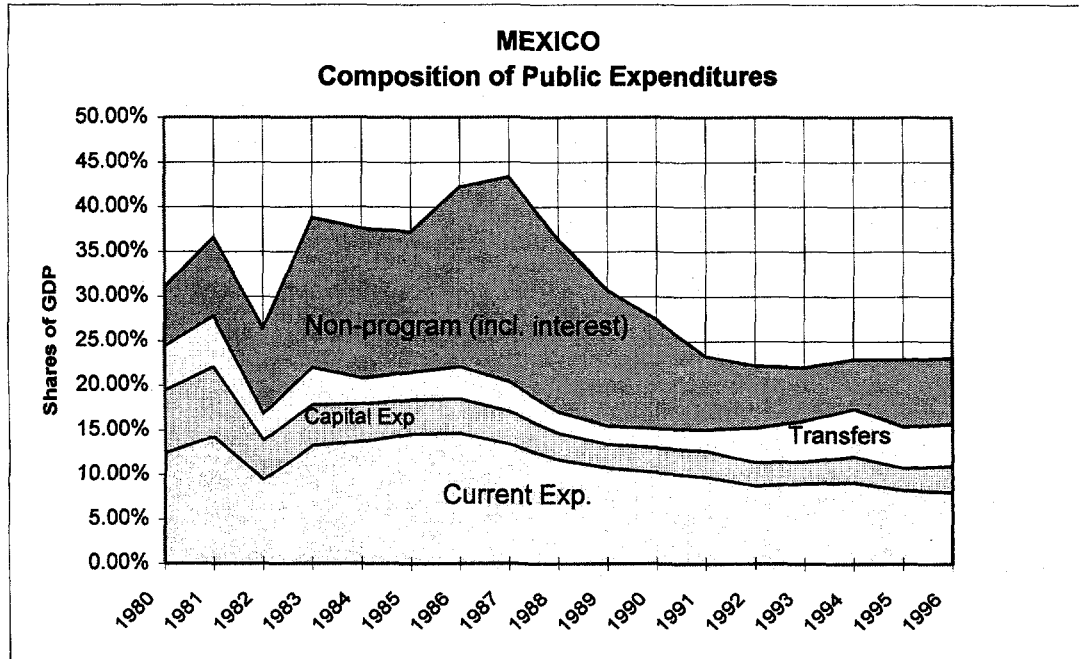
$$\frac{d(y(T) - y(0))}{d(s_G/\lambda)} = \frac{b_G}{(K^G/Y)^*} - \frac{b_C}{(C^G/Y)} = \frac{0.22}{1.07} + \frac{0.29}{0.08} = 3.83$$

- Crowding-out effects -- the preceding two results do not take into account the possibility of crowding out of private capital. The earlier time series estimates suggested that increases in public investment crowded out private investment by a factor of around 0.50. The full impact of a change in public capital can be estimated by imposing the further condition that $d(K^G/Y)^* = -0.5 d(K^P/Y)^*$, in the preceding derivations. That results in the subtraction of the term $[0.5]b_P/(s_P/\lambda) = [0.5][0.20]/1.73 = 0.058$ from the previous two results. In other words, the estimated impact of a debt-financed increase in public investment would be to reduce growth by a factor of -0.26, while a government consumption-financed increase would raise growth by a factor of +3.77.

The main conclusion suggested by the preceding derivations is that public investment would only have a clear positive impact on growth in Mexico if it is financed by equal reductions in government consumption expenditures. In that case, Mexico hardly has any leeway for stimulating growth in this manner because its level of current expenditures is already at rock bottom levels. As described in Figure 1, total public expenditures have declined significantly since the mid-1980s. While most of that decline took place in non-discretionary interest expenditures, programmable consumption spending also experienced a significant contraction and it is now among the lowest in the world as a share of GDP. Further cuts will be extremely difficult to achieve, especially in view of many new fiscal commitments that have emerged in the wake of the pension reform and banking support programs, and that may emerge in the future in response to pressures arising from the pattern of increased earnings inequality that has developed over the last decade.

steady-state public capital ratio, which implies raising the public investment ratio 0.35 % of GDP, would cause a 20-year growth rate decline of only 0.93 percent, or less than 0.05 percent per year.

¹⁹ Using the same reasoning as in the preceding footnote, a 10 percent increase in the steady-state public capital ratio financed through correspondingly lower government consumption, would raise the 20-year growth rate by 41 percent, under the old parameter ratios, and by 17.9 percent under the current public investment ratios. These respectively translate into annual growth rates of 2% and 0.9%.

Figure 1

Source: Banco de México, *Indicadores Económicos*, various issues.

Fortunately, the constraints facing Mexico in this regard are not quite as paralyzing as they may seem at first sight. For a start, it has to be kept in mind that the preceding parameter estimates reflect average behavioral relationships across countries and as they pertained over a particular period in time. To the extent that Mexico can improve the quality of its public investments, both relative to the cross-country average and relative to its own past performance, there is hope that its public investment program could make a stronger contribution to growth. In this context, an improvement in quality means paying closer attention to the choice of public investments so that it complements private economic activity (thereby resulting in less crowding out and more crowding in of private investment) and results in a more efficient use of public capital (thereby raising its rate of return). Stated differently, if public investments are carried out in the same manner as before, then its impact on growth is anticipated to remain very limited. Only by improving the process of identifying and preparing investment projects, with more attention to social rates of return, can a more significant growth impact be achieved.

F. Concluding Summary

The preceding analysis provides limited support to the claim that the decline in public investment since the 1970s contributed in some measure to the decline in Mexico's total factor productivity growth. However, it also suggests that increases in public investment will not automatically translate into faster output and productivity growth. One reason why a positive relationship between more public investment and faster growth cannot be taken for granted is the high crowding out effect that appears to have characterized public investments in the past. Another is that the positive relationship between public investment and productivity growth appears to have

weakened in the 1990s. Finally, the scope for generating faster growth by correcting past resource misallocations -- through reductions in "wasteful" public consumption in favor of higher public investment -- also has become much more limited. Therefore, the only way to assure that the public investment program makes a significant contribution to growth is by improving the quality of public investment through careful attention to its rate of return and complementarity to private capital.

The most important reform in terms of raising the quality and productivity of public investment followed from the Government's recognition of the need for a clearer distinction between the roles of the public and private sectors. This resulted in the privatization of most parastatal enterprises and a reorientation of public investment toward a more narrowly focused set of activities. The Government also recognized the need to strengthen the institutional framework within which the public investment program is determined. Accordingly, an Investment Unit was created in the Finance Secretariat (SHCP) in 1992 to be in charge of evaluating and prioritizing public investment expenditures.²⁰ In 1995, this Unit was merged with a parallel unit that had been in charge of the divestiture and privatization program. Under the current system, each public executing agency is required to prioritize its program of proposed investments, including rates of return analyses, prior to its submission to Congress as part of the fiscal budget. This represents an important improvement in terms of institutionalizing the notions of prioritizing and of giving attention to economic returns when defining the public investment program. Also, the merger of the former Divestiture Unit with the current Investment Unit represented an important step in terms of creating greater consciousness within the Investment Unit about the need to distinguish between the role of the public and private sectors. Both steps are expected to yield projects with higher returns and should help reduce the degree of crowding out of private investment in the future.

May 1998

²⁰ This Unit, officially named "Unidad de Inversiones y de Desincorporaciones de Entidades Paraestatales", was created as part of an institutional reorganization that fused the former Budget and Programming Secretariat with the Finance Secretariat.

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